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Session 1B

Kentucky Water Resources Research Institute, University of Kentucky

A NUTRIENT MONITORING PROJECT FOR THE PENNYROYAL ECOREGION OF KENTUCKY

Justin Smith
Center for Water Resource Studies, WKU
1906 College Heights Blvd. Bowling Green, KY 42101
(270) 303-0411
justin.smith2@wku.edu

The Center for Water Resource Studies at Western Kentucky University is conducting a nutrient monitoring project for the Pennyroyal ecoregion of Kentucky. A gap in nutrient data exists for the Pennyroyal ecoregion in the Commonwealth of Kentucky. This ecoregion is characterized by karst topography with sink holes, sinking streams, springs and caverns. The goal of this project is to collect and analyze nutrient data to assist the Kentucky Division of Water (KDOW) in establishing nutrient criteria in the Pennyroyal ecoregion.

The first step of this project was to identify and finalize all sampling sites. KDOW contacted EPA-Corvallis to select 50 original sites and 50 overdraft sites based on a probabilistic design. Half of the sites are within sub-ecoregion 71e, the Western Pennyroyal Karst Plain, and half are within 71g, the Eastern Highland Rim. Site reconnaissance was conducted and sites were selected based on accessibility. If an original site was not accessible, a site from the overdraft pool was used to replace it and the rationale for the change was documented. A total of 50 sites, 25 from each of the two sub-ecoregions, have been determined. The locations of final sampling sites were recorded using Global Positioning System (GPS) technology.

After the sampling sites were established, the first sampling event was conducted by Center for Water Resource Studies (CWRS) field operations personnel. A total of three sampling events will be conducted; Fall 2009, Spring 2010, and Summer 2010. During each sampling event, grab samples will be taken at the 50 sites identified during project planning. Samples will be collected for the following parameters: nitrate, nitrite, ammonia nitrogen, total Kjeldahl nitrogen, and total phosphorus. Two of the sampling events will be conducted during ambient and low-flow conditions, and one will be conducted during wet-weather conditions.

During each sampling event, water quality parameters are also measured using a multi-probe instrument. Using the YSI 6920 V2 Sonde; pH, dissolved oxygen (DO), water temperature (Tw), and specific conductivity (SpC) are recorded.

After the sampling events, all water quality samples will be analyzed at the WATERS Laboratory at WKU for required parameters and reported to approved detection limits.

CWRS will contribute real time results at the symposium based on data accumulated in Fall 2009 campaign. Although no previous nutrient data exists for the Pennyroyal, this project will set numeric standards on nutrient criteria for this region of Kentucky.

Nutrients, such as nitrates and phosphates, are distinct from other pollutants in that they are not only naturally present in bodies of water, they are necessary to maintain healthy aquatic ecosystems. Run-off from agriculture, and discharges from certain industries, can cause imbalances in nutrient levels that disrupt local ecosystems. It is hoped that once numerical standards for nutrient criteria have been established it will be possible to measure the consistency of nutrients in our water systems. A plan will be implemented by the KDOW to monitor the waters regularly to ensure the waterways are within the numerical standard set by the state to appease the Clean Water Act of 1998. With this knowledge KDOW will be able to identify where the impairments are centralized and steps will be taken to restore the waterways accordingly.

FEATURE CORRECTION TOOLS
DEVELOPED FOR RURAL WATER DISTRICT MAP CORRECTION

Karla Andrew, CFM, GISP
Center for Water Resource Studies
Western Kentucky University
1906 College Heights Blvd.
Bowling Green, KY 42101
Karla.andrew@wku.edu

In the course of developing an application under a grant from the Kentucky Science Technology Corporation (KSTC) to export Geographic Information Systems (GIS) features to an EPANET model, it was found that some rural water districts need slight corrections to GIS data. Tools were developed for GIS that include merging lines, adding missing junction points, estimating elevation of points, and more. This presentation will go over the issues that were found with data from rural water districts, the need for tools to correct features, and the tools that were developed for this project.

Additionally low or no cost tools currently available were utilized and documented for use in the system.

Issues found and tools developed:

- Mains not split at intersection with mains
  Plainarize Lines within GIS was used to correct this issue in our case. Functions need developed to evaluate issues involving mains crossing as opposed to intersecting. Within the developed toolset this could be replaced with mains being split at junctions allowing for the event of crossing where no junction exists.
- Mains not split at junctions (meters, fittings, etc)
  A tool was created to split the line segments at point features.
- Junctions missing
  This tool will use line data to find locations where points for junctions are missing. If a line endpoint doesn't match a point from any of the map point layers and has only two lines attached, the two lines will be merged.
  - Merge Tool – In some cases these mains should not be joined.
    A tool was also developed to join mains where two lines intersect or add a junction point if more than two lines are intersecting.
- Elevation data missing in many locations -
  The tool developed uses a Raster coverage to fill in missing elevation data. A user entered field allows for correction of estimated value to allow for depth of feature.
- Missing main segments
  The tool developed allows the user to select a segment and will select all connected lines using the select intersecting in an iteration. In a pipe network all the lines should be connected and any that are then not selected are disconnected pipes.

- Junctions not snapped to mains.
  A tool from Hawth's was utilized to correct for this. This tool required the M and Z values to be removed from the feature layer. – A python script was used for this purpose
    - Future tools may include a utility to snap lines to points, as the points are likely to result from GPS measurements in the field.

Additional issues included:

- Meter Locations not matching address information in water usage file.
- Length Values missing

These tools have been developed using the ESRI ARCGIS SDK for .NET. For information about tool availability: email cwrs@wku.edu.

BRIDGING THE GAP INTO THE WATER INDUSTRY

Christal Wade
Center for Water Resource Studies
Western Kentucky University
1906 College Heights Blvd #11094
Bowling Green, KY 42101
Phone: 270.780.2565
Email: christal.wade@wku.edu

The looming 'brain drain' coupled with non-competitive wages, an increasing training burden, and the perception that water and wastewater operator and technician positions are professions of last resort, create a challenge acknowledged by both state regulatory agencies and the water resource professionals charged with maintaining capacity. The effects of the retiring Baby Boomer generation have been exacerbated in the water and wastewater industry. The large numbers of Baby Boomers working for water/wastewater utilities will result in a large wave of retirements in the next 10 years. The water/wastewater industry will lose a great deal of tacit (undocumented) knowledge. As much as 80% of useful operational knowledge is tacit. Certain skills that utilities need when replacing workers are in short supply and are forecasted to get worse. In addition, few utilities report that they have succession plans in place and many publically-owned utilities operate under personnel rules that limit the ability to implement succession planning. Where plans are in place, much attention has been placed on succession planning for leadership positions and less emphasis has been paid to mission critical professional level positions.

Current training levels need to be upgraded and expanded. As regulations in the water and wastewater industry become more stringent, there is a lack of quality people entering the field and operators are being required to take on increasing responsibilities and to understand complex regulatory issues. Operators face increased expectations in both occupational and professional competencies. Increasing automation of utilities calls for more technically skilled workers. To complicate the matter, today’s pool of non-degreed workers has fewer skills than candidates have displayed in the past. The available supply of desirable workers is thin and water/wastewater utilities have difficulty competing with other employers for the best hires. The achievement of a post-secondary education may be the key to acquiring the skills needed in today’s water/wastewater workforce. Graduates of post-secondary programs tend to possess critical-thinking skills with the foresight to recognize potential problems and be more adaptable to change. However, competition for employees entering the workforce from colleges and trade schools is fierce. Potential entry-level employees are being lured away by higher-paying, higher-prestige jobs in consulting and other technical industries such as petroleum.

Federal regulations require that operators of water and wastewater treatment, distribution, and collection systems be certified/licensed and obtain continuing education to maintain this certification/licensure. Some college coursework (such as courses taught in the Water Resource Management Associate Degree program at Bowling Green Community College of Western Kentucky University) has been approved for continuing education credit for operators. In addition, for currently certified/licensed operators, college coursework can be substituted for years of experience, allowing them to advance at a faster pace in the industry. In an effort to have a broad reach, the aforementioned, Water Resource Studies program, is an on-line Associate Degree program. Accredited on-line courses and degree programs equal traditional face-to-face programs in meeting students needs, access to faculty, and interaction with other students. The on-line course environment offers students unparalleled flexibility with no set class schedule and no travel time. Academically, on-line courses are equally as rigorous as face-to-face classes. On-line courses also give students several advantages in their professional development: students are exposed to technology that they will use as tools in their current or future jobs, learn to manage deadlines, and play a key role in their own learning process.

DEPLOYMENT OF SENSOR NETWORKS FOR MONITORING WATER QUALITY USING RULE-BASED EXPERT SYSTEM IN GIS

Paige Davenport, Dr. Ernest, Karla Andrew, Shalini Chitrapu
WKU STH 2108, Bowling Green, KY 42101
(270) 745-2761
Kimberly.davenport@wku.edu

The Center for Water Resource Studies aims to help rural communities efficiently and cost-effectively complete the deployment of sensors and sensor networks for monitoring water supply systems in a user-friendly environment with the aid of a rule-based expert system embedded in a geographical information system (GIS) platform. The design-basis involves developing a customized sensor and control/response network, a rule-based expert system, and the analysis, display and response methods that enhance a unique spatial visualization to promote interactions between the designers, the operators, and the end-users. System costs will be minimized by using the expert system to design a sensor network that triggers response based on changes in overall system state, rather than the more expensive route of detecting specific intrusions with vector-specific sensors.

The EPANET toolkit was used to set up simulations of hydraulic and water quality scenarios. Outputs from EPANET were analyzed by engineers and experts for creating rules and assessment of sensor deployment. Types, amounts, and locations of sensors were assessed based on the historical water usage data and the simulation outcomes from EPANET. Spatial data of the water distribution network was converted and exported into the EPANET file format. Simulations were conducted based on multi-dimensional scenarios. EPANET offers various capabilities including hydraulic and water quality assessments. Spatial data is imported into EPANET software as .INP file format. The simulation was set to run for 72 hours. Once complete simulations of the network are assessed, the next step is to deploy sensors based on the needs. Determinations will be made on recommendation of the types, the number, and the locations of sensors needed.

A rule-based expert system is software that provides the knowledge of an expert in answering a problem for which a human expert would normally be consulted. This is accomplished by using a rule base, facts, and an inference engine. The rule base is the knowledge of an expert. The facts are the information about the real world problem or environment. The inference engine analyzes the rules and facts to produce a result to answer the problem.

Simple rules-based engines chain procedural logic together in an order that the user specifies. Most offer sophisticated matching algorithms like Rete to connect facts with rules, determine which rules should be run, and in what order. Rete builds a tree from the rules, like a state machine. Facts enter the tree at the top-level nodes as parameters to the rules, and work their way down the tree if they match the conditions until they reach the leaf nodes: rule consequences.

There are two types of chain procedural logic for a rule system: Forward Chaining and Backward Chaining. Forward chaining is "data-driven." It is reactionary with facts being searched against the inference rules until the desired result is found. Backward chaining is "goal-driven," meaning that it starts with a list of goals and works backwards to see if there are data which will allow it to conclude any of these goals.

The rule-based expert system was created by modifying a rule engine, jDREW and the extension OO (Object-Oriented) jDREW. jDREW is an easily configured, powerful deductive reasoning engine for clausal first-order logic (facts and rules) written in Java. jDREW uses Prolog and RuleML formats. It is both backward and forward reasoning.

OO jDREW contains a rule base, a place for facts, and an induction engine. Rules and facts are stored in the RuleML format. The rule base is initially created based on the knowledge of an expert. The facts are dynamically created with each project based on the spatial data provided by the user. The inference engine processes the data using forward chaining and/or backwards chaining to produce the result.

New tools were developed and integrated into the rule-based system to increase usability and cross functionality with many other existing programs. This was accomplished by adding conversion capabilities to the program. The conversion tool was created with the OGR Simple Features Library which is an open source library written in C++ programming language. This tool allows users to convert existing GIS data into many different formats.

The GML format was chosen to be the standard format used in this project. It was chosen because it is the open source standard used by the Open Geospatial Consortium (OGC) and is an XML schema. Many of the software already mentioned can use the GML format. Several popular open source software, including GRASS and MapWindow GIS, use the format as well.

The rule-based system converts GIS data to the GML format. A parser written in Java programming language was created. The parser takes the GIS data that is in the GML format and translates it into a RuleML file. The RuleML file is used in the rule engine OO jDREW to create a fact base. The parsing component dynamically locates each GIS data set and places them into separate relations within the RuleML file and associates the data sets attributes into relating variables. After OO jDREW creates results based on facts and rules then the RuleML is parsed into GML and added to the GIS as a new layer. The goal of using the GML format is to increase usability. The GML format is becoming an industry standard. The GML format helps make the rule-based system compatible with many of the most popular GIS software packages.